JAIMT
JOURNAL OF ARTIFICIAL INTELLIGENCE AND MODERN TECHNOLOGY
ISSN: 1595-6261 VOLUME 3, ISSUE 1 (MAY) 2025
A Peer Reviewed (Refereed) International Journal

THE IMPACT OF WEBSITE LOADING SPEED ON SEARCH ENGINE OPTIMIZATION AND USER ENJOYMENT

MFON, REBECCA NSOPIKPO
Department of Computer Science, Akwa Ibom State Polytechnic, Ikot Osurua.
Email: mfon.rebecca@akwaibompoly.edu.ng
D.O.I: 10.5281/zenodo.16099606

ARTICLE INFORMATION

Received: 12th March, 2025
Accepted: 21st April, 2025
Published: 20th May, 2025

KEYWORDS: Website Speed, Search Engine Optimization, Page Load Time, User Experience (UX)

JOURNAL URL:
https://ijois.com/index.php/jobpef

PUBLISHER: Empirical Studies and Communication (A Research Center)
Website: www.cescd.com.ng

This work is licensed under the Creative Commons Attribution International License (CC BY 4.0).

Open Access

http://creativecommons.org/licenses/by/4.0/

ABSTRACT

Website speed has become a critical determinant of online visibility and user engagement in the digital era. This paper examines the influence of website speed on search engine optimization (SEO), emphasizing its dual role as both a direct ranking factor and an indirect influencer of user behavior metrics such as bounce rate, dwell time, and page engagement. With Google's increasing focus on user experience, particularly through initiatives like mobile-first indexing and the introduction of Core Web Vitals, website speed has evolved from a mere technical concern to a strategic priority in digital marketing and search engine ranking strategies. The study explores how key performance indicators namely, Largest Contentful Paint (LCP), First Input Delay (FID), and Cumulative Layout Shift (CLS) impact SEO performance by reflecting real-user experiences. Furthermore, the paper highlights the risks associated with slow website performance, including diminished search rankings, lower organic traffic, and reduced user trust. Practical recommendations are provided, advocating for consistent performance monitoring, adoption of best development practices, and a balanced approach to rich content delivery and speed optimization. Ultimately, the findings underscore that website speed is indispensable for achieving and maintaining competitive advantage in today's search-driven digital marketplace.

INTRODUCTION

The digital economy has become a critical space for business operations, marketing, communication, and service delivery. At the heart of this digital revolution is the website a primary channel through which organizations and individuals interact with the global audience. As the number of websites grows exponentially, competition for visibility and user attention has intensified. Consequently, website performance, particularly loading speed, has emerged as a vital determinant of online success (Google, 2023). Website loading speed refers to the time it takes for a web page to fully display its content to users after they request it. Faster loading websites tend to retain visitors longer and offer a better user experience, while slow loading websites often suffer from high bounce rates and low engagement (Patel, 2021). In fact, a study by Portent (2022) highlights that the first five seconds of page load time have the highest impact on conversion rates, with each additional second causing a significant drop in engagement.

From a technical perspective, website speed affects how users interact with a site and directly influences their overall experience. However, beyond user perception, website speed has become a key factor in search engine optimization (SEO). Google, the leading search engine, officially announced in 2010 that site speed would be one of the signals used in its search ranking algorithms (Google, 2010). This announcement underscored the strategic importance of website performance not only for user engagement but also for search visibility. Moreover, as web access increasingly shifts to mobile devices, loading speed becomes even more critical. Mobile users typically have lower patience thresholds and may abandon sites that take more than a few seconds to load (Think with Google, 2022). In response, search engines like Google introduced mobile first indexing and included Core Web Vitals as ranking factors, which directly assess loading performance (Google Search Central, 2023). Therefore, understanding the interplay between website loading speed, SEO, and user engagement is paramount for businesses, digital marketers, and web developers. The relevance of this study is situated within this context to examine the impact of website loading speed on both search engine performance and user interaction metrics.

Despite advancements in web technology, many websites continue to suffer from performance issues, particularly slow loading speeds. This problem persists across various sectors, affecting both small scale businesses and large enterprises. While aesthetics, functionality, and content are emphasized during web development, performance optimization is often neglected or treated as an afterthought (Sullivan, 2020). The consequences of slow loading websites are multifaceted. Firstly, user engagement tends to decline as users abandon pages that take too long to load. Research suggests that 53% of mobile users leave a site if it takes longer than three seconds to load (Think with Google, 2022). Secondly, from an SEO standpoint, slow page speed can lead to lower search rankings, thereby reducing organic traffic and potential conversions (Moz, 2023).

This situation presents a significant challenge for businesses seeking to leverage digital platforms for growth. Without a clear understanding of how website speed influences both SEO and user engagement, web administrators may fail to achieve optimal digital performance. The problem is further compounded by the evolving algorithms of search engines and the growing expectations of users. As search engines prioritize user experience signals, including page load speed, websites that ignore these aspects risk losing competitiveness. Hence, there is a critical need to explore this issue systematically and provide empirical insights on the implications of website loading speed on both search engine optimization and user engagement.

Overview of Website Speed

In the digital era, website speed has emerged as a critical factor determining the success of online platforms. Website speed, often referred to as page load time, is the measure of how quickly the content on a webpage is displayed to the user after a request is made. It reflects both the technical performance of a website and its capacity to deliver a seamless user experience (Google, 2023). As internet users grow increasingly impatient with slow loading sites, businesses and organizations are compelled to prioritize website speed to enhance engagement, improve search engine rankings, and retain competitive advantage. Website speed is fundamentally influenced by several technical elements, including server response time, page size, the number of HTTP requests, and the efficiency of code execution (Souders, 2007). Server response time refers to how fast a web server responds to a browser request, which is critical because delays at this stage can significantly slow the overall loading process. The size of web pages, determined by the amount of content such as images, videos, scripts, and CSS files, directly affects load time. Larger pages naturally take longer to load, especially over slower internet connections (Google, 2023).

HTTP requests, the calls made by a browser to load individual components of a page (like images, CSS files, or JavaScript), can compound load time if they are numerous or inefficiently structured. Furthermore, unoptimized scripts or bulky code can degrade a website's performance, leading to prolonged loading times (Cutroni, 2010). Techniques such as code minification, image compression, leveraging browser caching, and using content delivery networks (CDNs) have become standard practices to counteract these challenges (Lindenberg & Fiedler, 2020). The significance of website speed is multifaceted. Firstly, it plays a crucial role in user experience (UX). Numerous studies have demonstrated a direct correlation between website speed and user engagement. A delay of just one second in page response can result in a 7% reduction in conversions, 11% fewer page views, and a 16% decrease in customer satisfaction (Akamai Technologies, 2017). This indicates that even marginal improvements in website speed can have a profound impact on business outcomes. The expectation for fast loading pages is even higher on mobile devices, where users often access content on the go and may have limited bandwidth (Google, 2018).

From a search engine optimization (SEO) perspective, website speed has been recognized as a key ranking factor by major search engines like Google. In 2010, Google officially announced that website speed would influence search rankings, citing its commitment to improving user experience (Google, 2010). This emphasis was further reinforced in 2018 when Google rolled out the "Speed Update," making page speed a ranking factor for mobile searches (Google, 2018). Therefore, faster websites are more likely to rank higher in search engine results pages (SERPs), attracting more organic traffic. The impact of website speed extends beyond immediate UX and SEO considerations. It also influences the emotional response and perceived credibility of a website. Slow websites often frustrate users, leading to negative emotional reactions that diminish trust in the site or brand (Bouch, Kuchinsky & Bhatti, 2000). Users may perceive a slow website as unprofessional or unreliable, particularly in competitive industries where alternatives are readily available. Conversely, a fast, responsive website conveys efficiency and professionalism, fostering positive user perceptions and loyalty (Nielsen, 2012).

Moreover, website speed plays a critical role in bounce rates and dwell time. Bounce rate refers to the percentage of visitors who navigate away from a site after viewing only one page. According to research by Google, as page load time increases from one to five seconds, the probability of bounce increases by 90% (Google, 2018). Dwell time the amount of time a user spends on a website before returning to the search results also correlates with website speed,

as users are more inclined to explore content on sites that load swiftly (Cutroni, 2010). These behavioral metrics are increasingly being used by search engines as indirect signals of website quality and relevance.

Another dimension of website speed is its impact on e commerce and revenue generation. For online retailers, milliseconds can equate to millions in revenue. Amazon famously reported that a 100 millisecond increase in load time could result in a 1% decrease in sales (Kohavi & Longbotham, 2007). Similarly, Walmart observed that improving page load time by one second increased conversion rates by up to 2% (Walmart Labs, 2012). These statistics underscore the direct relationship between website performance and business profitability. The growing complexity of websites, with rich multimedia content, interactive features, and third party scripts, presents ongoing challenges for maintaining optimal speed. Modern websites often integrate various plugins, analytics tools, social media feeds, and advertisements, all of which can contribute to load time if not properly managed (Lindenberg & Fiedler, 2020). Consequently, website developers and administrators must balance the desire for rich functionality with the need for speed optimization.

To address these challenges, several best practices and optimization techniques are widely recommended. Image optimization, through methods such as compression and the use of next gen formats like WebP, can significantly reduce load times without compromising visual quality (Google Developers, 2023). Minification of CSS, JavaScript, and HTML reduces file sizes by eliminating unnecessary characters, thereby improving load speed. Leveraging browser caching allows repeat visitors to load content more quickly by storing certain files locally on their devices. Additionally, adopting asynchronous loading for JavaScript ensures that scripts do not block the rendering of other elements on the page. Using CDNs to distribute content across multiple servers globally helps reduce latency by serving users from geographically closer servers (Lindenberg & Fiedler, 2020). Server side optimizations, including efficient database queries and server caching, further enhance website responsiveness.

Website speed monitoring and testing have also become integral to performance management. Tools like Google PageSpeed Insights, GTmetrix, Pingdom, and Lighthouse provide actionable insights and recommendations for improving load times. These tools assess various performance metrics, including First Contentful Paint (FCP), Time to Interactive (TTI), and Largest Contentful Paint (LCP), helping webmasters identify bottlenecks and prioritize optimization efforts (Google Developers, 2023). The mobile first indexing policy adopted by Google further emphasizes the need for website speed optimization on mobile platforms. With mobile traffic surpassing desktop usage globally, ensuring that websites load quickly and efficiently on mobile devices is no longer optional but a necessity (Statista, 2024). Mobile performance optimization strategies, such as responsive design, adaptive images, and mobile friendly layouts, are essential components of a comprehensive website speed strategy. Emerging technologies also hold promise for enhancing website speed. The adoption of HTTP/2 and the upcoming HTTP/3 protocols offers significant improvements in data transmission efficiency and security (Google Developers, 2023). These protocols enable features like multiplexing, header compression, and faster TLS handshakes, contributing to reduced load times. Similarly, the use of Service Workers and Progressive Web Apps (PWAs) can create near instant load experiences, particularly for repeat visits, by caching assets and enabling offline access.

Website as a Marketing Tool

The website is a collection of different web pages which are running under one domain name such as www.google.com. Website and web pages are using interchangeably, but one website can contain many web pages (Website 2014). The website is a collection of documents, graphics or information where a user can have the complete experience according to their need. There are two types of website, static and dynamic. A static website is usually created by using HTML and CSS which display the same information for a very long time. Static websites are very uncommon these days. Whereas Dynamic websites become popular because of their usability and easy to update functionality. A dynamic website is easy to maintain through a simple browser interface. Having a website became essential for any kind of businesses since the internet is available to everyone.

According to Kotable & Helsen (2001), the use of ICT in marketing is being practised on e business and e commerce in the 1990s. E commerce through Internet has changed customer's expectation concerning price, comparability, speed, and services. The integration of ICT with business improves efficiency and competitiveness of the company. It can connect customers, employees, and suppliers through communications and transaction. ICT plays a significant role in marketing to create value for customers. Nowadays, marketing is an essential aspect of any business to achieve their goal successfully. There are other ways to do marketing for business but since the availability of internet become more common, using website became one of the most powerful marking tools for business. Internet and website have played a vital role to run the business smoother than before. Creating companies own website could be a better way for a company to communicate with their potential customers. The website is playing a vital role in the customer and company by sharing and exchanging product information or the services.

Core Web Vitals: Loading, Interactivity, and Visual Stability

Among the Core Web Vitals, LCP measures the time until the largest visible page element renders, providing the most direct loading time insight. Google recommends an LCP threshold of 2.5 seconds or faster, with penalties accruing to pages that fail this standard. Sites that move from poor to passing LCP status frequently experience average improvements of nearly 3.7 positions for competitive search queries alongside an average 27 % increase in organic traffic. INP (which has replaced FID as of mid 2023) captures responsiveness over multiple user interactions, with a passing threshold of 200 ms. While FID previously carried moderate ranking correlation, INP's broader scope is expected to strengthen that signal moving forward. **CLS**, which measures visual stability, also plays a strong role particularly in mobile search ranking. Pages that reduce CLS below 0.1 often see traffic lifts of up to 21 %, with real world evidence of a nearly 18 % increase in "near me" local search impressions for improved sites. Collectively, these metrics not only improve user perception of site speed but also provide measurable SEO advantage.

How Website Speed Influences SEO

Website speed has transitioned from being a technical concern to a strategic component of digital marketing and search engine optimization (SEO). As search engines prioritize delivering the best possible user experience, website speed has emerged as a significant ranking factor in search algorithms. This growing importance is driven by the understanding that faster websites improve user satisfaction, reduce bounce rates, and enhance overall engagement factors that search engines like Google aim to reward with better visibility in search results (Google, 2021). The most straightforward way website speed influences SEO is through its role as a direct ranking factor. Google officially announced in 2010 that page speed would be included in its ranking algorithm, particularly for desktop searches (Google, 2010). This

initiative stemmed from research showing that users prefer websites that load quickly and tend to abandon slow loading pages. In 2018, Google extended this focus by introducing the Speed Update**,** which made page speed a ranking factor for mobile searches as well (Google Search Central, 2018). With the rise of mobile internet usage, this update emphasized the need for website owners to optimize load times across all devices. Google's algorithm now assesses both lab and field data to evaluate site speed, with a strong focus on Core Web Vitals metrics that capture real user experiences related to loading time, interactivity, and visual stability (Google Developers, 2023). Sites that perform poorly on these metrics may experience lower search rankings, making speed optimization a direct path to improving search visibility. Beyond its role as a direct ranking factor, website speed profoundly affects various user behavior metrics that search engines monitor as indirect indicators of a site's quality and relevance. Key metrics influenced by website speed include bounce rate, dwell time, and pages per session.

Influence of Website Loading Speed on Search Engine Optimization

Website loading speed affects SEO through several direct and indirect mechanisms. Search engines, particularly Google, evaluate various performance signals to determine how websites rank on search engine results pages (SERPs). Among these signals, page speed has emerged as a critical factor due to its impact on user experience, crawlability, and ranking algorithms. The following outlines the key mechanisms by which loading speed influences SEO:

Search Engine Ranking Algorithms: Google's algorithm updates have repeatedly emphasized the importance of page speed. Since the 2010 announcement of page speed as a ranking factor, Google has integrated speed related metrics into its ranking considerations (Google, 2010). In 2018, the "Speed Update" made page speed a ranking factor for mobile searches (Google Search Central, 2018). With the 2021 introduction of Core Web Vitals, metrics such as Largest Contentful Paint (LCP)**,** First Input Delay (FID), and Cumulative Layout Shift (CLS) became part of the ranking criteria (Google Search Central, 2023). A slow website may still rank if other SEO factors are strong, but given competitive markets, faster loading sites have a comparative advantage.

User Experience Signals and Behavioral Metrics: Search engines aim to deliver the best possible user experience. Google indirectly evaluates site quality through user engagement metrics such as:

- **Bounce Rate:** High bounce rates may indicate that users are dissatisfied with a site's performance, often caused by slow loading times.
- **Dwell Time:** The length of time users spend on a site before returning to the search results is a key indicator of relevance. Poor load speed can reduce dwell time.
- **Pogo Sticking:** This occurs when users click on a search result but quickly return to the search page to choose another link, signaling poor user experience.

These behavioral signals, while not explicitly declared as ranking factors, are believed to influence algorithmic learning models used by search engines (Moz, 2023).

Crawl Efficiency and Indexing: Search engines deploy web crawlers (bots) to index site content. These crawlers have a crawl budget, which is the number of pages a search engine will crawl within a given time. If a website loads slowly, crawlers may access fewer pages, leading to incomplete indexing (Patel, 2021). Faster websites enable more efficient crawling, ensuring that new content is indexed promptly and that the entire site remains visible in search engines.

Mobile First Indexing and Mobile Performance: With mobile first indexing, Google predominantly uses the mobile version of content for indexing and ranking (Google Search Central, 2019). Mobile users typically experience slower connections; hence, website speed on mobile is critical. Slow mobile page speeds may not only diminish user experience but also negatively affect SEO rankings in mobile searches.

SSL, Hosting, and CDN Integration

Modern SEO considers technical optimization, including secure connections (HTTPS), reliable hosting, and the use of content delivery networks (CDNs).

- **SSL Certificates:** HTTPS is a confirmed ranking signal (Google, 2014). Sites with SSL often enjoy slightly better ranking prospects.
- **Hosting and Server Response Time:** Faster hosting servers contribute to quicker load speeds.
- **Content Delivery Networks (CDNs):** CDNs distribute content closer to users, reducing latency and improving load times factors critical to both user experience and SEO.

Emotional Response and Perceived Credibility

The performance of a website, particularly its loading speed, plays a significant role in shaping users' emotional responses and perceptions of credibility. In an age where online interactions often form the first point of contact between businesses and potential clients, the speed at which a website loads can be the difference between engagement and abandonment. The psychological principle of first impressions suggests that individuals form initial opinions within a fraction of a second, and this extends to digital interactions. Lindgaard et al. (2006) affirm that users make aesthetic judgments about a website within 50 milliseconds. Although their research focused primarily on design, subsequent studies have shown that performance factors, especially loading speed, are equally influential in shaping first impressions.

When a website loads swiftly, it evokes positive emotional responses such as satisfaction, trust, and a sense of efficiency. These feelings encourage users to remain on the site, explore its content, and engage with its features. Conversely, a slow loading website often triggers negative emotions like frustration, annoyance, and disappointment. Such negative experiences can occur subconsciously and may result in immediate abandonment of the site. Siroker and Koomen (2013) note that users' patience for online interactions is limited, and delays in website performance often lead to a decline in user interest and eventual disengagement. Supporting this view, Gomez (2022) reported that 79% of users dissatisfied with a website's performance are less likely to return, indicating that the initial emotional response triggered by poor loading speed has lasting consequences on user behavior and loyalty.

Website speed also contributes to the perception of professionalism and technical competence. In the eyes of users, a fast loading website reflects a brand's commitment to quality and user experience. Fogg et al. (2003) argue that users often subconsciously assess the trustworthiness and credibility of a website based on both its visual appeal and functional performance. A site that responds quickly is likely to be associated with reliability, efficiency, and professionalism. On the other hand, a slow website may be perceived as a sign of poor management, technical incompetence, or lack of attention to customer needs. The Stanford Web Credibility Project (2022) found that 75% of users make judgments about a business's credibility based on its website's design and performance, demonstrating how critical loading speed is in forming

users' perceptions. In addition to shaping perceptions of professionalism, website speed directly impacts trustworthiness and user confidence. This is particularly relevant for e commerce platforms, online service providers, and websites handling sensitive user information. Kocher and Minarik (2021) emphasize that users are more likely to trust websites that load quickly, as speed is associated with security and reliability. When users encounter delays especially during crucial interactions like payment processing or data submission they may fear system errors, data breaches, or financial risks. Such doubts can result in the abandonment of transactions or hesitation to engage with the website altogether.

Beyond first impressions and initial trust, website speed plays a role in fostering long term brand loyalty and emotional connections with users. Positive digital experiences, supported by fast performance, contribute to higher levels of user satisfaction and repeat visits. Think with Google (2022) highlights that users who enjoy seamless digital experiences are more inclined to develop loyalty toward a brand, which is crucial in competitive markets where alternatives are readily available. In contrast, repeated negative experiences with slow loading sites diminish user retention rates and reduce the likelihood of word of mouth recommendations. Slow websites also increase users' cognitive load, which refers to the mental effort required to process information or complete tasks online. High cognitive load can lead to user frustration, distraction, and disengagement. The Nielsen Norman Group (2022) suggests that websites need to respond within one second to maintain a user's flow of thought and prevent disruption. When a website's response time exceeds this threshold, users are likely to become mentally fatigued or irritated, leading to higher bounce rates and reduced engagement.

Moreover, users often compare different websites offering similar services or products, especially in competitive industries. A slow loading website may be unfavorably compared with a competitor's site that performs efficiently, influencing users' decisions regarding where to invest their time or money. According to the Baymard Institute (2023), performance discrepancies between competitor websites significantly impact user loyalty and purchasing behavior, with users showing a clear preference for faster, more responsive sites. The emotional response to website performance also extends to customer reviews and online reputation. Users who experience frustration due to slow websites are more likely to leave negative reviews, share their dissatisfaction on social media, or warn others against using the service. Conversely, positive experiences often lead to favorable reviews and recommendations. HubSpot (2022) reports that 88% of online consumers are less likely to return to a site after a bad experience, underscoring the long term reputational risks associated with poor website performance.

Real world examples further illustrate these dynamics. For instance, Amazon revealed that a mere 100 millisecond increase in page load time could lead to a 1% decrease in sales (Kohavi & Longbotham, 2017). This statistic demonstrates the direct link between website performance, emotional response, and business outcomes. Similarly, Google found that a site loading in five seconds versus one second increased the probability of user bounce by 90%, a clear indication that speed significantly influences how users perceive value and relevance (Think with Google, 2022).

Website Speed Optimization Techniques and Tools

Achieving optimal website loading speed requires a combination of technical strategies and the use of specialized tools. As websites become more dynamic and content rich, ensuring fast load times becomes increasingly challenging yet essential for user engagement and search engine optimization (SEO). Website speed optimization involves systematically reducing the time it takes for a web page to load by addressing various performance factors, from server configuration to front end delivery. One of the foundational techniques in website speed

optimization is image optimization. Images often account for a significant portion of a webpage's size and loading time. Large, uncompressed images slow down page rendering, especially on mobile devices and slow networks. To mitigate this, images should be compressed without sacrificing quality using tools such as TinyPNG, ImageOptim, or WebP conversion. WebP is a modern image format developed by Google that provides superior compression and quality characteristics compared to traditional formats like JPEG and PNG (Google Developers, 2023). By adopting responsive image techniques and using proper size attributes, developers ensure that images do not overload the user's bandwidth or device capacity.

Another critical strategy is minification of code, which involves removing unnecessary characters such as white spaces, comments, and line breaks from HTML, CSS, and JavaScript files. Minified code reduces file sizes and improves parsing speed on browsers. Tools like UglifyJS, CSSNano, and HTMLMinifier are widely used in this regard. According to Patel (2021), minification can reduce page size by up to 30%, which directly translates into faster load times and better SEO performance. In addition to minification, combining files (also known as file concatenation) helps reduce the number of HTTP requests a browser must make to a server. By merging multiple CSS or JavaScript files into a single file, web developers can minimize server calls, thus decreasing latency and speeding up page load. However, with the advent of HTTP/2, which supports multiplexing, the need for file concatenation has diminished for some applications, though it remains a viable optimization for older protocols (Souders, 2018).

Browser caching is another essential optimization method. Caching stores certain elements of a website such as images, stylesheets, and scripts locally on a user's device. This means that when the user revisits the website, the browser can load cached elements instead of downloading them again. Properly configuring cache control headers allows for effective leveraging of browser cache, significantly reducing load times on repeat visits (Moz, 2023). Tools like Cache Control directives and service workers assist in setting up efficient caching mechanisms. One of the most impactful server side optimization strategies is the use of a Content Delivery Network **(**CDN**)**. A CDN is a network of geographically distributed servers that cache website content and deliver it to users from the nearest server node. This reduces latency and speeds up load times, especially for users located far from the origin server. Popular CDN providers include Cloudflare, Akamai, and Amazon CloudFront. Cloudflare (2023) reports that websites using a CDN can experience up to a 50% improvement in load speed for global users. Additionally, CDNs provide added benefits such as protection against Distributed Denial of Service (DDoS) attacks and enhanced site security.

Server response time optimization is also critical. A slow server response time delays the initial loading of the website. Improving server performance may involve upgrading hosting plans, optimizing server configuration, and reducing server side processing time. Using lightweight web servers like Nginx or implementing server side caching with tools like Varnish Cache can reduce response times significantly (Google PageSpeed Insights, 2023). Another powerful optimization technique is asynchronous loading of JavaScript and CSS resources. By default, browsers block page rendering until all scripts are fully loaded. However, using asynchronous or deferred loading allows critical content to render first, improving the perceived load time for users. Developers can use attributes like async and defer in script tags to control how scripts load in relation to other page content. This method ensures that JavaScript heavy applications do not slow down the display of visible page elements (Sullivan, 2020).

Lazy loading is an optimization strategy where certain website elements such as images or videos are loaded only when they are about to appear in the user's viewport. This reduces the

initial load time of the page and saves bandwidth. Lazy loading is particularly effective for long form content pages, blogs, and e commerce catalogs. HTML5 introduced native support for lazy loading with the loading="lazy" attribute, simplifying implementation (W3C, 2022). Another advanced method is code splitting, commonly used in modern JavaScript frameworks like React, Angular, and Vue.js. Code splitting involves breaking up large JavaScript bundles into smaller pieces that are loaded on demand. This ensures that only the necessary code for the current page is loaded, reducing the initial page load time and enhancing performance (Mozilla Developer Network, 2023).

The implementation of HTTP/2 and HTTP/3 protocols is a more recent server level optimization. These newer protocols offer significant performance improvements over the traditional HTTP/1.1 by enabling features like multiplexing, header compression, and faster TLS handshakes. HTTP/3, built on QUIC, further enhances performance, particularly on mobile networks with high packet loss (IETF, 2022). To effectively apply and monitor these optimization strategies, developers rely on various performance testing and analysis tools. Google PageSpeed Insights is one of the most popular tools, providing both mobile and desktop performance scores alongside detailed recommendations. It evaluates Core Web Vitals metrics and suggests practical improvements. GTmetrix offers a comprehensive analysis of page speed, waterfall breakdowns, and historical performance tracking. Lighthouse, an open source tool from Google, integrates with Chrome DevTools and provides audits for performance, accessibility, SEO, and best practices.

Additionally, WebPageTest.org is a powerful tool that allows for advanced testing, including testing from different geographical locations, browsers, and connection speeds. It provides in depth reports on load times, time to first byte (TTFB), and visual load progress (WebPageTest, 2023). The selection of optimization techniques and tools depends on the website's nature, the platform it is built on, and the target audience. For example, a global e commerce site might prioritize CDN deployment and image optimization, while a content focused blog may focus on lazy loading and minification. The key to effective website speed optimization is continuous monitoring, testing, and iterative improvements, ensuring that performance enhancements are aligned with both user expectations and SEO requirements.

Empirical studies

Many studies have been conducted to evaluate the quality of websites. Some have adopted the subjective website quality evaluation paradigm, using questionnaires to collect data relevant to research questions, while others have adopted the objective website quality evaluation paradigm, using qualitative models or diagnostic tools. To evaluate the quality of websites from users' perspectives, a questionnaire research instrument is often used as a data collection tool to ask users for their opinions on the websites. Jundillah et al. (2019) evaluated e learning websites based on the results of the Webqual questionnaire and calculations using the importance performance analysis method. The questionnaire was distributed to 95 students in various study programmes at Stikubank University in Indonesia. The parameters measured were the Webqual 4.0 measures for standard of usability, quality information, and service interaction. The study found that the average student was satisfied with the quality of e learning websites with which they interacted. Andalib and Danaee (2013) measured the quality of the website of Payame Noor University in Iran. The study considered the effects on customer loyalty of four quality parameters efficiency, accessibility, achievement, and security via two variables: trust and satisfaction. A questionnaire was used as the research instrument, administered to 387 active website users. A website quality parameter that seemed to be a major determinant of website quality was user satisfaction. The authors found that trust, efficiency, and achievement play an essential role in customer loyalty.

Almahamid et al. (2016) studied the website quality of Middle East University in Jordan. They found, through a quantitative study, that perceived usefulness and perceived ease of use are key determinants of behavioural intention in the use of the university website. Kravchenko et al. (2021) used a quantitative, model based methodology called website QEM (quality evaluation method) to assess the quality of two higher education websites in Ukraine. The authors focused on the following attributes: quality of content, quality of design, ease of use of the site for applicants, and students' reputation. Based on the parameters evaluated, Taras Shevchenko National University of Kyiv was found to be performing significantly better than Kyiv National University of Trade and Economics.

Kincl and Strach (2012) studied user satisfaction with 44 business school websites in the Czech Republic. They reported that user satisfaction is multidimensional: different features of the websites impact differently on the level of user satisfaction with the websites. They also documented evidence that users' inability to complete a task when on a website resulted in a significant negative effect on user satisfaction. Another study that investigated user satisfaction is that of Soruma et al. (2012), which found no positive correlation between website quality and user satisfaction. Elling et al. (2012) developed a website evaluation questionnaire (WEQ) specifically for governmental websites and focused on seven website quality parameters: ease of use, hyperlinks, structure, relevance, comprehension, completeness, and layout.

Furthermore, Akgul (2021) evaluated the accessibility, usability, quality performance, and readability aspects of all Turkish state and private university websites. The results from the study indicated low levels of accessibility, usability, quality performance, and readability. A variety of web diagnostic tools were used in the evaluation process, including, but not limited to, Google Mobile friendly Test for mobile responsiveness, Web Page Analyzer for quality performance test, Alexa Traffic Rank for website popularity ranking, CSS Validation Service and HTML Markup Validation Service. Numerous automated evaluations of website quality, using web diagnostic tools, have also been conducted. One of the earliest studies, by Choudrie et al. (2004), evaluated global e government sites using diagnostic tools, and discovered that significant work was needed in order to make the portals examples of "best practice" e government services. Shi (2006) found that significant work was needed to improve the quality of World Expo websites in order to provide quality information and services to their users. Jati and Dominic (2009) considered the quality of five Asian e government websites, using web diagnostic tools that checked for website performance, quality of links, markup validation, and accessibility. Their study revealed that the five e government websites were not performing optimally.

Conclusion

Website speed has proven to be a decisive factor in the overall performance of websites, particularly concerning search engine optimization (SEO). With increasing competition for online visibility, search engines like Google have embedded speed-related metrics such as page load time and Core Web Vitals into their ranking algorithms. These measures reflect a broader shift toward user-centric performance standards, where the quality of a user's experience directly influences a website's search visibility. The influence of website speed on SEO operates on multiple levels. Firstly, it serves as a direct ranking signal, affecting both desktop and mobile search results. Secondly, website speed indirectly influences SEO by impacting critical user behavior metrics like bounce rate, dwell time, and pages per session factors that search engines monitor as indicators of content relevance and quality. Moreover, with Google's mobile-first indexing and the growing dominance of mobile search traffic, the demand for

speed optimization on mobile devices has become non-negotiable for website owners seeking competitive advantage. The introduction of Core Web Vitals encompassing Largest Contentful Paint (LCP), First Input Delay (FID), and Cumulative Layout Shift (CLS) has further clarified the technical standards expected of web developers and digital marketers. Failure to meet these thresholds can result in diminished search engine rankings, reduced traffic, and poor user engagement. On the other hand, a well-optimized website that loads quickly and offers a seamless interactive experience not only ranks better but also fosters user trust, engagement, and conversion.

Recommendations

Based on the analysis of how website speed influences SEO, the following recommendations are suggested for website owners, developers, and digital marketers:

- Focus on achieving recommended thresholds for LCP, FID, and CLS. Use tools like Google Search Console, Lighthouse, and PageSpeed Insights to regularly monitor and address performance issues.
- Given the dominance of mobile-first indexing, ensure websites are fully responsive, load efficiently on mobile networks, and provide a seamless user experience on various devices.
- Adopt performance-enhancing practices such as image compression, code minification, leveraging browser caching, asynchronous loading of scripts, and reducing server response time.
- Deploy CDNs to serve content from geographically distributed servers, reducing latency and enhancing load speed for users across different regions.
- Make performance monitoring an ongoing task rather than a one-time activity. Regular audits and updates based on real-user data will help maintain optimal speed as web technologies and user expectations evolve.

References

Akamai Technologies. (2017). *The State of Online Retail Performance Report*. Akamai.

Baymard Institute. (2023). Cart abandonment rate statistics. Retrieved from https://baymard.com/lists/cart abandonment rate

Bouch, A., Kuchinsky, A., & Bhatti, N. (2000). Quality is in the eye of the beholder: Meeting users' requirements for Internet quality of service. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, 297 304.

Cloudflare. (2023). What is a CDN?. Retrieved from https://www.cloudflare.com/learning/cdn/what is a cdn/

Cutroni, J. (2010). *Google Analytics*. O'Reilly Media.

Fogg, B. J., Soohoo, C., Danielson, D., Marable, L., Stanford, J., & Tauber, E. R. (2003). How do users evaluate the credibility of Web sites?: A study with over 2,500 participants. Proceedings of the 2003 Conference on Designing for User Experiences.

Gomez. (2022). Why website performance matters. Gomez Performance Research.

Google Developers. (2023). *Core Web Vitals*. https://web.dev/vitals/

Google Developers. (2023). Optimize Images. Retrieved from https://developers.google.com/web/fundamentals/performance/optimizing content efficiency/image optimization

Google Developers. (2023). *PageSpeed Insights*. https://pagespeed.web.dev/

Google PageSpeed Insights. (2023). PageSpeed Insights. Retrieved from https://pagespeed.web.dev/

Google Search Central. (2021). *Understanding page experience in Google Search results*. https://developers.google.com/search/blog/2021/04/page experience update

Google Search Central. (2023). *Page experience and search performance*. https://developers.google.com/search/docs/appearance/page experience

Google Search Central. (2023). Understanding page experience in Google Search results.

Google. (2010). Using site speed in web search ranking. Google Search Central Blog.

Google. (2010). *Using site speed in web search ranking*. https://developers.google.com/search/blog/2010/04/using site speed in web search ranking

Google. (2018). *Speed Update: Page speed as a ranking factor for mobile searches*. https://developers.google.com/search/blog/2018/07/page speed ranking

HubSpot. (2022). The Ultimate List of Marketing Statistics for 2022. HubSpot Research.

IETF. (2022). HTTP/3 Explained. Internet Engineering Task Force. Retrieved from https://http3 explained.haxx.se/en/

Kocher, M., & Minarik, A. (2021). Online trust formation in e commerce transactions: The role of website performance. Journal of Business Research, 123, 45 58.

Kohavi, R., & Longbotham, R. (2007). Online controlled experiments and A/B testing. *Encyclopedia of Machine Learning and Data Mining*.

Lindenberg, J., & Fiedler, S. (2020). *Website Performance Optimization*. Packt Publishing.

Lindgaard, G., Fernandes, G., Dudek, C., & Brown, J. (2006). Attention web designers: You have 50 milliseconds to make a good first impression!. Behaviour & Information Technology, 25(2), 115 126.

Moz. (2023). Caching Best Practices & Max age Gotchas. Retrieved from https://moz.com/blog/http caching

Moz. (2023). Page Speed and SEO: A Comprehensive Guide.

Mozilla Developer Network. (2023). Code Splitting. Retrieved from https://developer.mozilla.org/en US/docs/Glossary/Code_splitting

Nielsen Norman Group. (2022). Response Times: The 3 Important Limits. Retrieved from https://www.nngroup.com/articles/response times 3 important limits/

Nielsen, J. (2012). *Usability 101: Introduction to Usability*. Nielsen Norman Group.

Patel, N. (2021). How Loading Time Affects Your Bottom Line. Neil Patel Digital.

Patel, N. (2021). How to Speed Up Your Website. Neil Patel Digital. Retrieved from https://neilpatel.com/blog/website speed/

Portent. (2022). Page Speed and Conversion Rates.

Siroker, D., & Koomen, P. (2013). A/B Testing: The Most Powerful Way to Turn Clicks Into Customers. John Wiley & Sons.

Souders, S. (2007). *High Performance Web Sites: Essential Knowledge for Front End Engineers*. O'Reilly Media.

Souders, S. (2007). *High Performance Web Sites: Essential Knowledge for Front End Engineers*. O'Reilly Media.

Souders, S. (2018). High Performance Browser Networking: What Every Web Developer Should Know About Networking and Web Performance. O'Reilly Media.

Stanford Web Credibility Project. (2022). Stanford Guidelines for Web Credibility. Retrieved from https://credibility.stanford.edu/

Statista. (2024). *Mobile internet usage worldwide*. Statista.

Sullivan, D. (2020). Why site speed matters more than ever. Search Engine Land. Retrieved from https://searchengineland.com/why site speed matters more than ever 329311

Think with Google. (2022). Why page speed matters: Research insights. Google Marketing Platform.

W3C. (2022). HTML Standard: Lazy Loading Attribute. Retrieved from https://html.spec.whatwg.org/multipage/embedded content.html#attr img loading

Walmart Labs. (2012). *How Walmart Improved Conversion with Site Speed*. Walmart Labs Blog

WebPageTest. (2023). Website Performance and Optimization Test. Retrieved from https://www.webpagetest.org/